UCRL-JC-124241 Sum

Results of Life-Cycle Testing for the National Ignition Facility First Wall Against Damage from Target Emissions and Decontamination Procedures

M. Tobin, A. Anderson, A. Burnham, R. Managan, T. Reitz, and T. Bernat
Lawrence Livermore National Laboratory (LLNL), Livermore, California 94550 USA

The energy emitted from NIF targets will vary from 1.8 MJ (the incident laser energy) to as much as 20 MJ for the largest expected yield, a factor of 10^5 increase over current experiments. This energy will be in the form of neutrons, x rays, ionic debris, shrapnel, and laser light (1ω, 2ω, and 3ω). These emissions can lead to damage of the target chamber first-wall and other in-chamber components, and to the final chamber optics. The final optics can also be degraded by subsequent condensates produced by x-ray absorption by the first wall and chamber components.

Calculations indicate that for hohlraum targets more than 50% of the non-neutron energy released from NIF targets will be in the form of x rays. The emission characteristics are non-isotropic with the emission from the wall of the hohlraum being a much longer pulse [~50 ns] and quite cold in temperature [~200 eV peak] compared to laser entrance hole emissions [~6 ns and 1 keV peak]. Nova experiments have been conducted to validate the model used for these predictions.

Experiments to test the first wall and final optics response to the x rays have been conducted on Nova and compared to damage predictions. An approximately equivalent NIF irradiation condition was created by determining the fluence of the ~ 1ns Nova x-ray pulse at ~200 eV blackbody temperature that created the same peak front surface temperature as the predicted NIF irradiation on the candidate first wall material, either thermal sprayed or hot pressed B_4C.

For direct drive, about one-third of the incident 3ω light is refracted by the target corona and scattered to the first wall creating a 4-ns fluence of ~0.3 J/cm^2. Experiments were conducted with both 1ω and 3ω fluences ranging from 0. 3 to several J/cm^2 and from 3 ns to 60 ns.

Experimentally observed damage from x rays and 3ω irradiation range from a slight roughening of the surface to 'mud-cake cracking' due to expansion and subsequent shrinkage of the material as it cools. The combination of predictions and experimental results allow cautious predictions concerning the survivability of the NIF first wall and its contribution to debris shield degradation due to material ejection under x-ray loading.

Experiments have also been conducted to determine what the potential erosion may be of the first wall due to CO_2 pellet cleaning of the first wall surface. This is periodically necessary to prevent build-up of target debris that would begin to be re-deposited on optics surfaces if an increasingly thick layer was to form. Predictions have been made and x-ray exposure experiments have been conducted to determine how much of a layer can be tolerated before CO_2 cleaning must restore the surface to a debris-free state.

Actual operating conditions for the NIF first wall will include all of the threats discussed above occurring on a periodic basis. In order to determine the impact of all of these phenomena together, so-called life cycle testing has been conducted. We have repeatedly exposed samples of first wall material, both hot-pressed and thermal sprayed B_4C, to target emissions in the Nova facility for up to one week at a time, performed CO_2 decontamination cleaning of the surfaces, and examined for damage and wear to confirm that both the higher cost hot-pressed and lower cost thermal spray B_4C will meet NIF specifications for first wall wear.

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract no. W-7405-Eng-48.